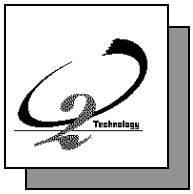

O_2 Graph
User Manual

Release 5.0 - April 1998

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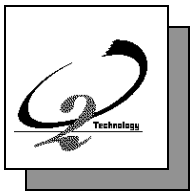
Who should read this manual

Visualization of objects and their relations can enhance presentation. This manual describes O_2Graph, a graphical editor that links two or more objects. Various O_2Graph layouts are available: trees, grids, graphs, etc. An O_2Graph toolbox is provided with predefined classes: Graph, Node, Link and GraphDialoguer.

Other documents available are outlined, click below.

See O2 Documentation set.



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1 O_2 Graph

This manual explains how to use O_2 Graph in order to display your database objects in a graph.

This chapter is divided into the following sections:

- System Overview
- Introduction
- The background

1 O2 Graph

1.1 System Overview

The system architecture of O_2 is illustrated in Figure 1.1.

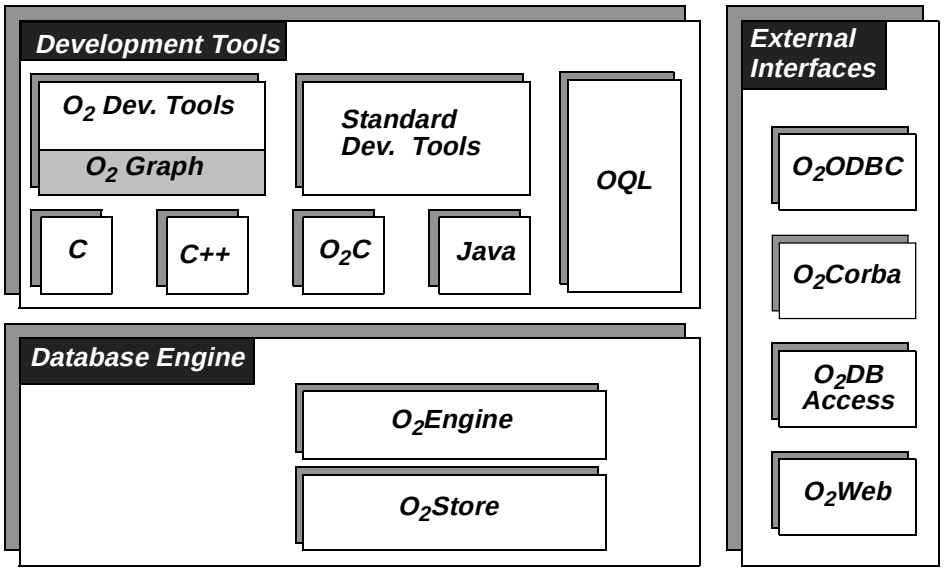


Figure 1.1: O_2 System Architecture

The O_2 system can be viewed as consisting of three components. The Database Engine provides all the features of a Database system and an object-oriented system. This engine is accessed with Development Tools, such as various programming languages, O_2 development tools and any standard development tool. Numerous External Interfaces are provided. All encompassing, O_2 is a versatile, portable, distributed, high-performance dynamic object-oriented database system.

Database Engine:

- O_2Store — The database management system provides low level facilities, through O_2Store API, to access and manage a database: disk volumes, files, records, indices and transactions.
- O_2Engine — The object database engine provides direct control of schemas, classes, objects and transactions, through O_2Engine API. It provides full text indexing and search capabilities with O_2Search and spatial indexing and retrieval capabilities with O_2Spatial. It includes a Notification manager for informing other clients connected to the same O_2 server that an event has occurred, a Version manager for handling multiple object versions and a Replication API for synchronizing multiple copies of an O_2 system.

Programming Languages:

O_2 objects may be created and managed using the following programming languages, utilizing all the features available with O_2 (persistence, collection management, transaction management, OQL queries, etc.)

- C — O_2 functions can be invoked by C programs.
- C++ — ODMG compliant C++ binding.
- Java — ODMG compliant Java binding.
- O2C — A powerful and elegant object-oriented fourth generation language specialized for easy development of object database applications.
- OQL — ODMG standard, easy-to-use SQL-like object query language with special features for dealing with complex O_2 objects and methods.

O_2 Development Tools:

- O_2Graph — Create, modify and edit any type of object graph.
- O_2Look — Design and develop graphical user interfaces, provides interactive manipulation of complex and multimedia objects.
- O_2Kit — Library of predefined classes and methods for faster development of user applications.
- O_2Tools — Complete graphical programming environment to design and develop O_2 database applications.

Standard Development Tools:

All standard programming languages can be used with standard environments (e.g. Visual C++, Sun Sparcworks).

External Interfaces:

- O_2Corba — Create an O_2/Orbix server to access an O_2 database with CORBA.
- O_2DBAccess — Connect O_2 applications to relational databases on remote hosts and invoke SQL statements.
- O_2ODBC — Connect remote ODBC client applications to O_2 databases.
- O_2Web — Create an O_2 World Wide Web server to access an O_2 database through the internet network.

1 O2 Graph

1.2 Introduction

A *graph editor* is any graphic display that connects two or more objects with links. It can be used with different layout policies to represent trees, graphs, networks, etc. Certain interactive manipulations are allowed on a graph editor.

O_2Graph provides a specific editor called **`graph`** which may be invoked to perform these functions. The **`graph`** editor is a mask that may be used to display an O_2 value of a particular structure; the value specifies the set of *nodes* of the graph, as well as the set of *links* that connect the nodes. Additional information (background of the graph, position of each node against the background, content of each node, shape of each link, optional label for each link, scale) may also be given in the value. If permission is granted, the user may move nodes, insert new nodes, insert new links, remove nodes, and remove or redraw links.

1.3 The background

The background display of a **`graph`** editor may be a bitmap image (black and white) or a pixmap image (color), or nothing at all. The schema presented in the section below defines the background as a **`Drawable`**. This O_2 class is defined in the **`o2kit`** schema. Two sub-classes of **`Drawable`** are also defined: the **`Bitmap`** class and the **`Image`** class. A method is defined for these two classes to initialize objects with bitmaps or images.

This method is named **`loadfile`**. The **`loadfile`** method takes one parameter and is invoked as:.

- *drawable***`->loadfile (`***unixfile***`);`**

where:

- *drawable* is an instance of the class **`Bitmap`** or the class **`Image`**.
- *unixfile* is a Unix path to an X11 bitmap file if *drawable* is an instance of the class **`Bitmap`**, or to a GIF file if *drawable* is an instance of the class **`Image`**.

In order to use these classes in an O2 schema, you must import them from the **`o2kit`** schema using the following syntax: **`o2kit:Schema import schema o2kit class Drawable, Bitmap, Image;`** Once a

background has been defined, the nodes of the graph may be positioned at particular points of the background. Each point is specified with horizontal and vertical coordinates (*x* and *y*). These coordinates may be chosen simply (that is, with the top left corner of the background being coordinate (0, 0) and other values representing distances in screen pixels from this point); or they may be expressed in more human-friendly terms, such as centimeters, miles, or degrees of longitude and latitude. In that case, a distinction is made between “screen size” and “real size” (as explained in Chapter 2).

Alternatively, you can let the **`graph`** editor itself take the responsibility for positioning the nodes. Four *layout managers* are available for this purpose (Chapter 4). If a layout manager is used, the point coordinates of each node are ignored (or realigned) and may be left unspecified.

1 O2 Graph

2 Data Structures

This chapter describes the various data used with the Graph editor.

2 Data Structures

The **graph** editor may be used to display any O_2 value whose type conforms to the following tuple specification. (O_2Kit contains a class with this structure; refer to Chapter 6 : O2Kit Toolbox Features for the Graph Editor):

```
type graph: tuple (origin:      tuple (x:     integer,
                                       y:     integer),
                   real_size:   tuple (width:    integer,
                                       height:   integer),
                   screen_size: tuple (width:    integer,
                                       height:   integer),
                     background:  Drawable,
                     nodes:       set (Node),
                     links:       set (Link));
```

This definition of the **graph** type refers to the following class definitions:

```
class Node
public type tuple (position:    tuple (x:     integer,
                                       y:     integer),
                     content:     <any>)
end;
class Link
public type tuple (drawing:     list(tuple (x:    integer,
                                            y:    integer)),
                     label:       <any>,
                     from:        Node,
                     to:          Node)
end;
```

The details on each of the attributes is as follows:

- **origin.x**: The horizontal offset of the background within a larger frame of reference. This is the distance, in any horizontal unit of measurement, from the *x*-axis of the larger frame to the left edge of the background display. If there is no larger frame of reference, this may be left zero.

- **origin.y**: The vertical offset of the background within a larger frame of reference. This is the distance, in any vertical unit of measurement,

from the *y*-axis of the larger frame to the top edge of the background display. If there is no larger frame of reference, this may be left zero.

- **`real_size.width`**: The width of the background display, expressed in the same units of horizontal measurement as used for **`x`**.

- **`real_size.height`**: The height of the background display, expressed in the same units of vertical measurement as used for **`y`**.

- **`screen_size.width`**: The width of the background display — the same as **`real_size.w`**, except expressed in pixels. The **`graph`** editor uses this information to determine how to convert from the user-defined horizontal coordinates to pixels.

- **`screen_size.height`**: The height of the background display — the same as **`real_size.h`**, except expressed in pixels. The **`graph`** editor uses this information to determine how to convert from the user-defined vertical coordinates to pixels.

- **`background`**: The background of the **`graph`** display. This may be an object of the class **`Bitmap`** or **`Image`** or one of their subclasses. If the user does not want to have a background, nothing should be assigned to this field.

  The background specified here is used to tile the graph window (whose size is specified in the fields above). Tiling is the laying out of a background image to cover an area. The background image is applied at the origin (top left corner) of the window. Another copy of the same background image is applied next to the first one, and another below it, and so on until the window is filled. This process fills the background of the graph with many copy of the same image or bitmap. To have only one representation of a bitmap or an image in the background of the graph, the size of the background specified in this field should be the same as the **`screen_size`** specified above.

- **`nodes`**: A set of objects of class **`Node`**. Each element represents a node of the graph.
  - **`position.x`**: The horizontal position of the node, with respect to the overall frame of reference and in the same units of horizontal measurement used in **`origin.x`** and **`real_size.width`** above.
  - **`position.y`**: The vertical position of the node, with respect to the overall frame of reference and in the same units of vertical measurement used in **`origin.y`** and **`real_size.height`** above.

- **content**: The O_2 object to be presented in the node. An O_2 value may also be specified here. The object is presented in the node according to the mask specified in the **lk_specific** function (see Chapter 3 : Presentation and Display).

- **links**: A set of objects of class **Link**. Each element describes a link between two nodes in the graph.
  - **drawing**: A list of values of type **point**. The two nodes given in the fields below are linked together with a polyline, described with this list of points. This list may be left empty, in which case a simple line is used to connect the two nodes. (This field is ignored if a layout manager is used.)

    x: The horizontal position of one end of the polyline, with respect to the overall frame of reference and in the same units of horizontal measurement used in **origin.x** and **real_size.width** above.

    y: The vertical position of one end of the polyline, with respect to the overall frame of reference and in the same units of vertical measurement used in **origin.y** and **real_size.height** above.
  - **label:** The O_2 object or value to be used as a label for the link. An O_2 value may also be specified here. The label appears in the middle of the link if the resource **showLabel** is set to true; if the resource is set to false, this field is ignored.
  - **from**: An object of class **Node**. This object must also appear in the **nodes** field of the same **graph** value. This node represents the starting point of the link.
  - **to**: An object of class **Node**. This object must also appear in the **nodes** field of the same **graph** value. This node represents the ending point of the link.

Warning !

When designating an arc **from** a given node A **to** another node B, only this link is then allowed. You cannot then designate on the same two nodes an arc **from** node B **to** node A.

3 Presentation and Display

This chapter describes how to define a presentation for your objects, values, and so forth. It also details the various resources offered by the Graph Editor for this presentation.

3 Presentation and Display

3.1 Overview

A value of type **graph** may, of course, be displayed with the usual tuple and list masks. In order to make use of the special features of a **graph** value, however, a specific editor mask must be created using the **lk_specific** mask function, as explained in the *O2 Look Manual*. For the **graph** specific editor, **lk_specific** must be called as follows:

lk_specific (*ed_name***,** *rcount***,** *resources***, "graph",** *mcount***,** *masks***)**

Such a **graph** mask may *only* be invoked upon a value whose structure conforms to that described in Chapter 2. The arguments of the **lk_specific** mask function are as follows:

- *ed_name*: A string representing the widget name of the mask. This name may be used in a resource file to specify graphic resources for this individual mask (refer to the *O2 Look Manual*).
- *rcount*: An integer count of the number of special resources given in the *resources* argument.
- *resources*: A pointer to an array of graphic resources to be customized in the mask (unless *rcount* is zero). Each resource in the array is of type **Lk_resource**. For details on the specification of resources in this way, refer to the *O2 Look Manual.* A list of resources for the **graph** editor is given below.
- **"graph"**: This is the name of the specific editor to create.
- *mcount*: the number of sub-masks used by this specific editor. This should be either 1 (if link labels are not displayed) or 2 (if they are displayed).
- *masks*: A pointer to an array of sub-masks (i.e. values of type **Mask**) used in this specific editor. The number of masks in this array is *mcount*. The first mask in the array will be used to display the content of the nodes; the second (if any) is for the label of the links.

Note

When you define the presentation for an object of the class Graph, you use the function **lk_present**. Please note that the background attribute

is set to nil after **lk_present** and you must save the graph background beforehand and restore it afterwards if you want to use the same background. For example :

```
o2 Drawable d;
         o2 Graph obj;
         Lk_presentation p;
            ...

         d=obj->background;
         p=lk_present(obj, lk_object(0, 0,0,
                           lk_specific(0, 0, 0, ‘‘graph’’, 0, 0)));
         obj->background=d;
```

3.2 General graph resources

The **graph** editor may use any of four different layout managers, or no layout manager (in order to specify the coordinates of the nodes using the **position** attributes). The layout policy is specified in the **layout** and **doLayout** resources; the other graphic resources available to the specific editor mask depend, in part, upon the layout policy used.

The following table lists the graphic resources which may be customized for any **graph** mask, regardless of layout policy; these resources are specified using the **lk_specific** function, either in a resource file in association with the *ed_name* argument, or directly in the *resources* argument of the function

Table 1.1 ***Graphic resources***

Name	Type	Default	Access
arrowStyle	char	’ ’	CS
arrowHeight	int	12	CS
arrowWidth	int	6	CS
attachFrom	string	center	CS
attachTo	string	center	CS
autoLinkSelect	Boolean	True	CS
doLayout	Boolean	False	CS
hMargin	int	10	CS
hSize	short	0	CS

Table 1.1 ***Graphic resources***

Name	Type	Default	Access
hSizeMax	Boolean	False	CS
layout	string	null	C
linkColor	Color	Dynamic	CS
linkNewProcess	Boolean	False	CS
linkThickness	short	2	CS
maxHeightVisible	short	300	CS
maxWidthVisible	short	300	CS
minHeight	short	20	CS
minWidth	short	20	CS
moveProcess	Boolean	False	CS
multiLinkProcess	Boolean	False	CS
nodeCutProcess	Boolean	False	CS
nodeNewProcess	Boolean	False	CS
replaceProcess	Boolean	False	CS
resizeProcess	Boolean	False	CS
selBorder	Boolean	True	CS
selColor	Color	Dynamic	CS
selectProcess	Boolean	False	CS
selThickness	short	4	CS
showLabel	Boolean	False	CS
vMargin	int	10	CS
vSize	short	0	CS
vSizeMax	Boolean	False	CS

- **`arrowStyle`**

  Specifies the graphical aspect of the arrows. If arrows are not wanted, this resource should be set to the character **' '** (one blank); otherwise, the character **'>'** should be used.

- **`arrowHeight`**

  Specifies the length of arrows along the link direction, in pixels. Typically, **`arrowHeight`** is twice **`arrowWidth`**.

- **`arrowWidth`**

  Specifies the thickness of arrows (orthogonal to the link direction), in pixels.

- **`attachFrom`**

Specifies where the starting point of links are attached to nodes. The possibilities are:

- **`center`** (or **`default`**): Links join “underneath” the center of the node (i.e. the node hides the ends of the links).
- **`top`**: Links join at the center of the top edge of the node.
- **`bottom`**: Links join at the center of the bottom edge of the node.
- **`left`**: Links join at the center of the left edge of the node.
- **`right`**: Links join at the center of the right edge of the node.
- **`top_left`**: Links join at the top left corner of the node.
- **`top_right`**: Links join at the top right corner of the node.
- **`bottom_left`**: Links join at the bottom left corner of the node.
- **`bottom_right`**: Links join at the bottom right corner of the node.

In all cases, a node will hide any part of a link that occupies the same space as the node.

- **`attachTo`**

  Specifies where the ending point of links are attached to nodes. The possibilities are the same as for **`attachFrom`**, and the default is **`center.`**

- **`autoLinkSelect`**

  Determines whether links between selected nodes are automatically selected. If true, selecting two nodes will automatically select any link between them, independently of the explicit selection state defined by the end user.

- **`doLayout`**

  Specifies whether a layout manager should be invoked. If true, the layout manager specified in the **`layout`** resource governs the construction of the graph presentation. If false (or if the **`layout`** resource is set to **`null`**), then no layout manager is used, and the position of each node is determined by the value of the **`position`** attribute of each object of class **`Node`**.

- **`hMargin`**

  Specifies the horizontal distance, in pixels, from the left edge of the graph presentation to the left edge of the leftmost node, and from the right edge of the rightmost node to the right edge of the graph

presentation.

- **`hSize`**

  Specifies the width of all nodes (unless the **`hSizeMax`** resource is set to true), in pixels. If zero (the default), each node will have its own natural width (and they may all be different).

- **`hSizeMax`**

  If set to true, all nodes have the same width, namely the current maximum width of all the nodes of the graph. If set to false (the default), the value of the **`hSize`** resource governs the node widths.

- **`layout`**

  Specifies the layout manager to use, if the **`doLayout`** resource is set to true. The possibilities are **`grid`**, **`tree, isi, spring`**, and **`null`**; each is described in a separate subsection below. In addition, each layout manager allows the specification of its own graphic resources, listed in separate tables below. If the **`layout`** resource is **`null`** (the default), then no layout manager is used, even if **`doLayout`** is set to true.

  This resource can be set only at creation time.

- **`linkColor`**

  Specifies the color of the lines used to draw the links.

- **`linkNewProcess`**

  Determines whether the user can interactively add links between nodes (using the **`ControlShift`** keys plus the right mouse button).

- **`linkThickness`**

  Specifies the thickness (in pixels) of the lines used to draw the links.

- **`maxHeightVisible`**

  Specifies the maximum visible vertical size, in pixels, of the graph. If the vertical size of the graph is greater than this value, a vertical scrollbar appears on the left side of the graph window.

- **`maxWidthVisible`**

  Specifies the maximum visible horizontal size, in pixels, of the graph. If the horizontal size of the graph is greater than this value, an horizontal scrollbar appears at the bottom of the graph window.

- **minHeight**

  Specifies the minimum height, in pixels, of the **graph** editor. The actual height of the graph is dynamically changed to enclose all the nodes plus the vertical margin (the **vMargin** resource). If this size is less than the minimum height, then the minimum height is used instead.

- **minWidth**

  Specifies the minimum width, in pixels, of the **graph** editor. The actual width of the graph is dynamically changed to enclose all the nodes plus the horizontal margin (the **hMargin** resource). If this size is less than the minimum width, then the minimum width is used instead.

- **moveProcess**

  Determines whether the user can interactively move nodes around (using the **Shift** key plus the right mouse button).

- **multiLinkProcess**

  Specifies whether user-added links may or may not be made up of more than one line segment (i.e. jagged lines). If true, the user may click several times during the construction of a link, and each click that does not occur on a node will produce an “elbow” of the multi-segment link. Figure 1.2 shows an example of a multi-segment link.

- **nodeCutProcess**

  Specifies whether a cut operation (with the **Control** key plus the middle mouse button) can be performed on the **nodes** of a graph display. If set to **True**, the user may remove nodes from the graph.

- **nodeNewProcess**

  Determines whether the user can interactively add nodes (using the right mouse button).

- **replaceProcess**

  Specifies whether the contents of a node icon can be replaced with an O_2Look paste operation.

- **resizeProcess**

  Determines whether the user can interactively resize nodes (using the **Control** key plus the right mouse button).

- **selBorder**

Determines how to display selected nodes. If true, selected nodes are surrounded by a rectangle, whose color and thickness are specified by **selColor** and **selThickness**. If false, selected nodes have their background color set to **selColor**.

- **selColor**

  Specifies the color used to distinguish a selected node and link from an unselected one.

- **selectProcess**

  Determines whether the user can interactively select nodes and links (using the middle mouse button).

- **selThickness**

  Specifies the thickness, in pixels, of the selection outlines for the selected links, and for the selected nodes when **selBorder** is true.

  Selected links are drawn with two lines: one line using the **linkColor** and **linkThickness** resources, and one line using the **selColor** and **selThickness** resources. Depending on the relative values of **linkThickness** and **selThickness**, the thickest line is drawn first.

- **showLabel**

  Determines whether link labels are visible or not. If true, the link label (as specified in the **label** attribute of instances of class **Link**) is displayed superimposed upon the center of the link line.

- **vMargin**

  Specifies the vertical distance, in pixels, from the top of the graph presentation to the top edge of the topmost node, and from the bottom edge of the bottom-most node to the bottom of the graph presentation.

- **vSize**

  Specifies the height of all nodes (unless the **vSizeMax** resource is set to true), in pixels. If zero (the default), each node will have its own natural height (and they may all be different).

- **vSizeMax**

If set to true, all nodes have the same height, namely the current maximum height of all the nodes of the graph. If set to false (the default), the value of the **vSize** resource governs the node heights.

4 Layout Managers

This chapter offers some guidelines as to the overall layout possible with the GraphEditor and its various managers.

The chapter is divided into the following sections :

- ***The grid layout manager***
- ***The tree layout manager***
- ***The isi layout manager***
- ***The spring layout manager***

4 Layout Managers

4.1 The `grid` layout manager

The **`grid`** layout manager is a simple layout manager for the **`graph`** editor. It forces all nodes of the graph to occupy slots on a fixed rectangular grid, whose characteristics are determined by specific resources. This layout manager is useful when the exact position of the nodes is not important, but neatness is. If the position of a node is specified (in the **`position`** attribute), the **`grid`** layout manager places the node at the slot on the grid closest to the specified coordinates (without bothering to check if a node already occupies that slot). If no position is specified (that is, if the coordinates are both zero), then the manager assigns it to the first free slot that it finds. When a node is moved, the manager snaps the node into the slot closest to where the user dropped it, regardless of whether that slot is already occupied. The **`grid`** layout manager thus allows nodes to overlap, partially or totally.

The following table lists the graphic resources which may be customized for a **`graph`** mask using the **`lk_specific`** function and the **`grid`** layout manager, either in a resource file in association with the *ed_name* argument, or directly in the *resources* argument of the function :

Table 1.2 ***Corresponding O_2 and IDL types for export***

Name	Type	Default	Access
hGrid	int	80	CS
hOrigin	int	80	CS
horizontal	Boolean	True	CS
maxInRow	int	5	CS
vGrid	int	40	CS
vOrigin	int	40	CS

- **`hGrid`**

  Specifies the horizontal separation, in pixels, between the centers of adjacent nodes.

- **`hOrigin`**

  Specifies the horizontal coordinate of the center of the first node in each row. This is the distance, in pixels, from the left edge of the display.

- **horizontal**

  Specifies the main direction for the grid. If true, rows are filled one after another; a new row is started when the current row has **maxInRow** nodes. If **horizontal** is false, columns are filled one after another; a new column is started when the current column has **maxInRow** nodes.

- **maxInRow**

  Specifies the maximum number of nodes per row (if the **horizontal** resource is true) or per column (if **horizontal** is false).

- **vGrid**

  Specifies the vertical separation, in pixels, between the centers of adjacent nodes.

- **vOrigin**

  Specifies the vertical coordinate of the center of the first node in each column. This is the distance, in pixels, from the top edge of the display.

4.2 The `tree` layout manager

The **tree** layout manager is specialized in the display of hierarchical tree structures. A **graph** presentation using the **tree** layout manager is shown in Figure 1.1, The **tree** layout manager. Note that each node on the tree may be the destination of at most one link (the **to** attribute of the class **Link**), although it may be the source (the **from** attribute) of any number of links.The **tree** layout manager assumes that the

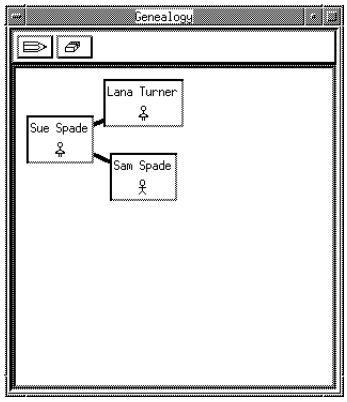


Figure 1. 2:The **`tree`** *layout manager*

links represented in the **`graph`** value conform to hierarchical rules (that is, no node may be the destination of more than one link). If this is not the case, the layout manager extracts a “forest” of trees out of the data anyway, using the following simple rules:

- If a node is not the destination of any link, it is the root of a tree.
- If a node is the destination of exactly one link, the source node of that link is the parent of this node.
- If a node is the destination of several links, all links but one are ignored (randomly), and the source node of the remaining link is the parent of this node.

The tree, or trees, that result from this selection are displayed according to some aesthetic principles:

- Nodes at the same level of the tree lie along a straight line. The lines defining the different levels are parallel.
- A parent node is centered over its children.
- Nodes at the same level are separated by a minimum distance.
- A subtree is drawn the same way regardless of where it occurs in the tree.
- The overall width of each tree is minimized.
- The trees of the forest are separated by a minimum distance.
-

The tree is dynamically reconfigured when nodes and links are added and deleted. For instance, if a node **`A`** is the destination of two links from nodes **`B`** and **`C`**, and if the link between **`A`** and **`C`** was ignored (according to the rules above), then that link will be reinstated if the user should delete the link between **`A`** and **`B`**. When a node is added to the graph and it is not the root of a new tree, it is automatically placed as the last child of its parent node.

The following table lists the graphic resources which may be customized for a **graph** mask using the **lk_specific** function and the **tree** layout, either in a resource file in association with the *ed_name* argument, or directly in the *resources* argument of the function.

Table 1.3 ***Graph resources***

Name	Type	Default	Access
hGap	int	10	CS
horizontal	Boolean	True	CS
linkClass	string	standard	CS
reversed	Boolean	False	CS
vGap	int	25	CS

- **hGap**

  Specifies the minimum horizontal distance, in pixels, between adjacent nodes. This is also the distance between the different trees of the forest when the direction is vertical.

- **horizontal**

  Specifies the main direction for the tree. If true, the children of a node are laid out on one side of their parent. If false, the children are laid out above or below their parent node. The final position depends also upon the **reversed** resource.

- **linkClass**

  Defines the style of links between nodes. There are three possibilities: **standard** (the default), which produces straight lines at any angle; **hvh**, which produces square-cornered multilines consisting of a horizontal line from the source node, a vertical line to the level of the destination node, and another horizontal line to the destination node; and **vhv**, which produces square-cornered multilines consisting of a vertical line from the source node, a horizontal line to the level of the destination node, and another vertical line to the destination node. The last two options are useful for dropchart-style graphs.

- **reversed**

  Specifies the orientation of the tree. If false, the children of a node are laid out to the right of their parent (if **horizontal** is True) or below their parent (if **horizontal** is False). If true, the children of a node are laid out to the left of their parent (if **horizontal** is True) or above their parent (if **horizontal** is False).

- **vGap**

Specifies the minimum vertical distance, in pixels, between nodes. This is also the distance between the different trees of the forest when the direction is horizontal.

4.3 The isi layout manager

The **isi** layout manager displays a direct acyclic graph or DAG. In a DAG, a node can be the destination of any number of links (**to** attribute of the class **Link**), or the source (**from** attribute) of any number of links. However, links in a DAG cannot form cycles. The **isi** layout manager extracts a DAG from the graph and displays it according to the layout **ISI Grapher** algorithm.[1] This algorithm lays out the *x* and *y* coordinates of the nodes independently:

- The *y* coordinate of a node without children (a “leaf”) is set so the nodes do not overlap vertically.
- The *y* coordinate of a non-leaf node is set to the average of the *y* coordinates of its children.
- The *x* coordinate of a node without parents (a “root”) is set to 0.
- The *x* coordinate of a non-root node is set to the right of all of its parents.

This is a very efficient layout manager. The time required for the layout algorithm to operate is linearly proportional to the number of nodes plus the number of links, making the **isi** manager very practical for large graphs. If the graph is not a DAG (that is, if it has cycles), it is turned into a DAG by arbitrarily ignoring one link per cycle for the sake of layout construction. (Ignored links are still drawn.) The display is dynamically reconfigured when nodes and links are added and deleted. For instance,

1. G. Robins, “The ISI Grapher: A Portable Tool for Displaying Graphs Pictorially”, ISI Reprint Series, USC/Information Science Institute, 4676 Admiralty Way, Marina del Rey, CA 90292-6695, USA.

if a link that was part of a cycle is deleted, the link that had been ignored in order to break the cycle is once again taken into account.

The following table lists the graphic resources which may be customized for a **graph** mask using the **lk_specific** function and the **isi** layout, either in a resource file in association with the *ed_name* argument, or directly in the *resources* argument of the function.

Table 1.4 ***Graphic resources***

Name	Type	Default	Access
hGap	int	10	CS
horizontal	Boolean	True	CS
reversed	Boolean	False	CS
vGap	int	25	CS

- **hGap**

Specifies the minimum horizontal distance between nodes. If the layout is horizontal, this is the minimum horizontal distance between a node and its parents. If the layout is vertical, this is the minimum horizontal distance between leaves.

- **horizontal**

Specifies the main direction for the DAG. If true, the children of a node are laid out on one side of their parent. If false, the children are laid out above or below their parent node. The final position depends also upon the **reversed** resource.

- **reversed**

Specifies the orientation of the DAG. If false, the children of a node are laid out to the right of their parent (if **horizontal** is True) or below their parent (if **horizontal** is False). If true, the children of a node are laid out to the left of their parent (if **horizontal** is True) or above their parent (if **horizontal** is False).

- **vGap**

Specifies the minimum vertical distance between nodes. If the layout is horizontal, this is the minimum vertical distance between leaves. If the

layout is vertical, this is the minimum vertical distance between a node and its parents.

4.4 The `spring` layout manager

The **`spring`** layout manager uses a spring model to display an arbitrary graph which is reshaped whenever a link or node is added, deleted or moved. All other links or nodes move to compensate for a change and an animation feature enables you to watch the process. The reshaping rules are based on spring dynamics calculations.

A distance *d* is defined over the graph nodes: the distance between two nodes is the shortest path length. Directly connected nodes have a distance of 1, and nodes in different unconnected components have an infinite distance. Each node pair with a finite distance *d* is linked by a spring whose strength is proportional to $1/d^2$.

The dynamic system of nodes and springs is stable when the distance between each node pair is *L* times the graph-distance between the nodes; *L* is the unit length and is specified in the **`length`** resource. When the system is stable, its energy is zero. When the system is unstable, the strengths of the springs determine a state with locally minimal energy. The graph is brought to a minimal energy each time the graph is changed. This is done by an incremental algorithm that takes each node to a stable position one by one until the energy changes by less than an epsilon between two algorithm iterations. This value is specified in the **`epsilon`** resource. At each stage, the node with the highest energy is moved.

The graph is dynamically reconfigured when nodes and links are added and deleted. When a node is moved or created, that node is pinned to where you placed it, and the other nodes move around it.[1] The animation feature that displays the successive states of the resolution as feedback. You can therefore easily follow layout modifications. It is also valuable when the graph is large and the reshaping takes a long time.

The following table lists the graphic resources for a **`graph`** mask using the **`lk_specific`** function and the **`spring`** layout, either in a resource file

1. If this were not the case, the node just moved would be the one with the highest energy, and would simply be tugged back to its initial position straight away.

in association with the *ed_name* argument, or directly in the *resources* argument.

Table 1.5 ***Graphic resources***

Name	Type	Default	Access
animate	int	10	CS
epsilon	int	10	CS
length	int	75	CS
maxIter	int	25	CS
maxLoop	int	10	CS

- **`animate`**

Specifies algorithm animation. If 0, none occurs. If positive, a graph outline is displayed at each algorithm step. The value specifies the number of steps and level of animation detail: if a node is moved by more than **`animate`** pixels, the move is decomposed into a number of submoves each of **`animate`** pixels.

- **`epsilon`**

Specifies minimum variation of graph energy between two iterations below which the algorithm stops. A small epsilon gives better results but is longer to obtain.

- **`length`**

Specifies unit link length (value *L*) in pixels. The algorithm tries to make all links this long. Raising or lowering this value loosens or tightens the springs controlling the layout.

- **`maxIter`**

Specifies maximum number of iterations for a single node. At each step, the algorithm chooses the node with maximum energy, and brings it to a (local) minimum energy position. This limits the number of iterations to reach this position.

- **`maxLoop`**

Specifies maximum loop number. If the graph has *n* nodes and the energy is not stable after *n* * **`maxLoop`**, the algorithm stops. This prevents loops being introduced by rounding errors.

5 Interactive Behavior

This chapter outlines the different possibilities enabling you to interact with the Graph editor.

5 Interactive Behavior

The following interactive behavior is defined for the **graph** editor. These actions may be restricted or prohibited through the use of graphic resources and layout managers.

- *Selection*: The left mouse button governs the selection of links and nodes. Clicking the left mouse button on a link or node causes it to be selected; holding the **Control** key down and clicking the left mouse button extends or toggles the selection.

  Clicking the left mouse button on the background of the **graph** editor and dragging it describes a rectangle; all nodes and links located entirely within this rectangle will be selected. Holding the **Shift** key down and clicking the left mouse button on the background permits the extension of the most recent rectangle used.

  A selection process can be cancelled by pressing the Escape key while the mouse button is down; any selected node or link can be "unselected" by holding the **Control** key down and clicking the left mouse button on that node or link.

- *Moving a node*: Holding the **Shift** key and clicking the right mouse button on a node permits dragging the node to a new position. It stays where it is when the mouse button is released, unless the layout manager forces it to go elsewhere.

- *Adding a new node*: A new node may be copied or cut from another O_2Look presentation and pasted onto a graph, provided of course that it is of the same type as the other nodes. In addition, the **GraphDialoger** feature permits another way of adding nodes; refer to Section 6.4."

- *Removing a node*: Moving a node to the O_2Look Clipboard removes it from the graph, and also removes all of its links.

- *Adding a link*: Holding both the **`Control`** and **`Shift`** keys down and clicking the right mouse button on a node, then dragging the mouse to a second node, establishes a new link between the two nodes. If the button is released against the graph background, an “elbow” in the link appears; in this way, a multiline link can be drawn between two nodes (see Figure 1.2). The link creation process can be cancelled by typing the Escape key while the mouse button is down.

- *Removing a link*: Links may only be removed under the control of the **`Graph`**Dialoger; refer to Section 6.4.

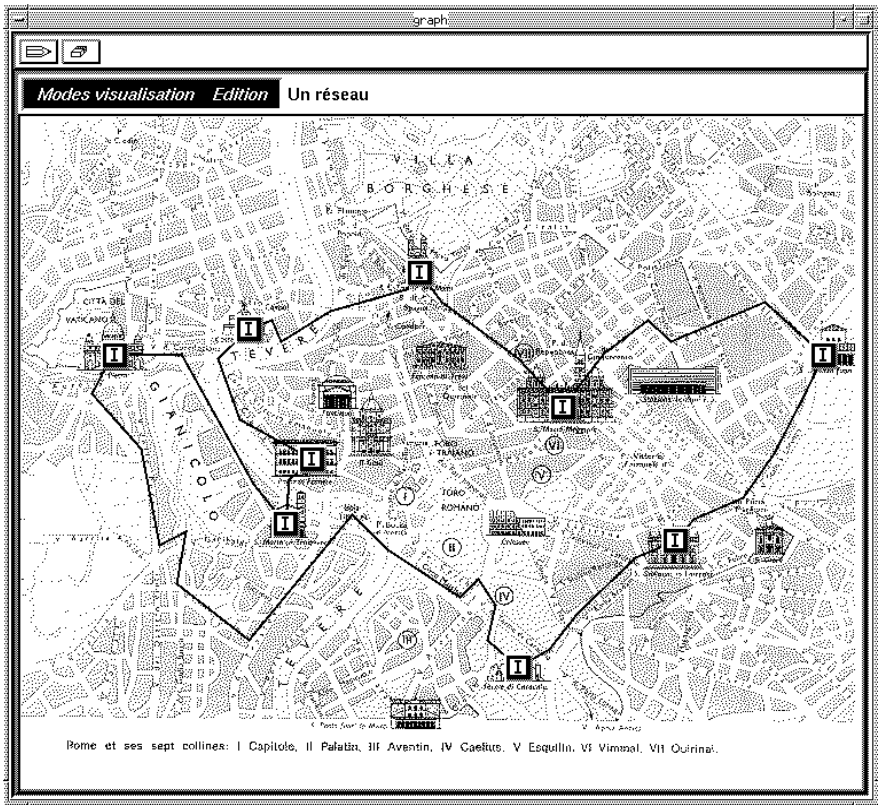


Figure 3.3: A **`graph`** *display with a multiline link*

5 Interactive Behavior

6 O_2Kit Toolbox Features for the Graph Editor

The O_2Kit toolbox (documented in the *O2 Look Manual*) supplies a set of predefined classes that conform to the data structures required by the **`graph`** editor (see Chapter 2 : Data Structures). However, the toolbox is flexible enough so that you can define subclasses to suit your particular needs.

O_2Kit classes contain methods that facilitate the construction of interactive graphic applications. You can import these classes into any schema from the system-supplied schema named **`o2kit`**.

The type structure and methods of the graph-related classes in O_2Kit are described in the following sections:

- **`The class graph`**
- **`The class Node`**
- **`The class Link`**
- **`The class GraphDialoger`**

6 O2Kit Toolbox Features for the

6.1 The class graph

The type structure of the class Graph conforms to that specified for graph values in Chapter 2 : Data Structures; in addition, its methods allow dynamic modifications to the content of the graph :

```
class Graph
public type tuple (origin: tuple (x: integer, y: integer),
                real_size: tuple (width: integer, height:
integer),
                screen_size: tuple (width: integer, height:
integer),
                    background: Drawable,
                    nodes: set (Node),
                    links: set (Link))
method ...
```

Important

If an application uses subclasses of the O_2Kit classes **`Node`** and **`Link`** , then a corresponding subclass of **`Graph`** should also be defined, whose attributes **`nodes`** and **`links`** take sets of the subclasses instead of **`set (Node)`** and **`set (Link)`**.

The methods of class **`Graph`** are numerous and very useful:

- ***set_origin (x: integer, y: integer)***

  Modifies the origin attribute of the receiver object (which is private).

- ***set_real_size (w: integer, h: integer)***

  Modifies the **`real_size`** attribute of the receiver object (which is private).

- ***set_screen_size (w: integer, h: integer)***

  Modifies the **`screen_size`** attribute of the receiver object (which is private).

- ***set_background (background: Drawable)***

Modifies the **background** attribute of the receiver object (which is private).

- ***add_node (n: Node): integer***

  Adds a node to the **nodes** attribute of the receiver object; always returns 1.

- ***remove_node (n: Node): integer***

  Removes the node **n** from the **nodes** attribute of the receiver object; returns 0 if the node **n** was not in **nodes** to begin with, and 1 otherwise.

- ***add_link (l: Link): integer***

  If **l** is a link between two of the receiver object's nodes, this method adds **l** to the **links** attribute of the receiver object and returns 1; otherwise it returns 0.

- ***add_link_between (n1: Node, n2: Node): integer***

  If **n1** and **n2** are among the graph's nodes, this method creates a new link between them and adds it to the **links** attribute of the receiver object and returns 1; otherwise it returns 0.

- ***remove_link (n1: Node, n2: Node): integer***

  Finds all links between **n1** and **n2** and removes them from the **links** attribute of the receiver object. The method returns 1 if any links were found, and 0 if none were found.

- ***delete_link (l: Link): integer***

  If **l** is an element of the **links** attribute of the receiver object, this method removes **l** from **links** and returns 1; otherwise it returns 0.

- ***remove_links (n: Node): integer***

Finds all links involving node n and removes them from the links attribute of the receiver object. The method returns 1 if any links were found, and 0 if none were found.

- ***get_links (n: Node): set(Link)***

  Returns the set of all links involving node **n**.

- ***get_nodes (n: Node): set(Node)***

  Returns the set of all nodes linked to node **n**.

6.2 The class Node

The class **Node** type structure conforms to that given in Chapter 2, with the important difference that there is no content attribute.

This enables you to define multiple subclasses of **Node** with **content** attributes of various types, according to the needs of particular graphic applications. An example appears in Section 6.5.

The public methods of class **Node** allow programs to read and write to the **position** attribute (which is private by virtue of the **import schema** command) :

.

```
set_position (x: integer, y: integer)
```

Modifies the **position** attribute of the receiver object :

```
get_position: tuple (x: integer, y: integer)
```

Returns the **position** attribute of the receiver object.

6.3 The class Link

The class **Link** type structure conforms to that given in Chapter 2, with the important difference that there is no **label** attribute. This enables you to define multiple subclasses of **Link** with **label** attributes of various types, according to the needs of particular graphic applications. An example appears in the Section 6.5.

The public methods of class **Link** allow programs to read and write to the **origin** and **destination** attributes (which are private by virtue of the **import schema** command)

```
get_origin: Node
```

Returns the **from** attribute of the receiver object

```
get_destination: Node
```

Returns the **to** attribute of the receiver object

```
set_origin (n: Node)
```

Modifies the **from** attribute of the receiver object

```
set_destination (n: Node)
```

Modifies the **to** attribute of the receiver object.

6.4 The class GraphDialoger

The **GraphDialoger** class, like the O_2Kit **Dialoger** class, has several useful methods. Objects of this class are useful to you but are never seen by your end-user. The methods of the **GraphDialoger** class manipulate an O_2Look presentation displaying a **Graph** object. Some operations (such as adding and removing links and nodes) are similar to those methods of the class **Graph**, except that the methods of class **Graph** operate directly upon an object of that class, whereas the methods of class **GraphDialoger** operate only upon an O_2Look presentation. Only when the “Pencil” button is clicked are these operations reflected in the object being displayed. As a programmer, you do not have to know what the type structure of the class **GraphDialoger** as it is handled totally transparently

```
class GraphDialoger
private type tuple (editor: integer,
                    active: boolean,
                   triggers: list (tuple (event: integer,
                                          target: integer,

                                   method: string)
```

The **editor** attribute identifies the O_2Look presentation to be manipulated by the **GraphDialoger** methods; the **initialize** method (see below) establishes this link. The **active** attribute, as its name implies, distinguishes between mapped and unmapped presentations. The **triggers** attribute is a list of user interactions and the methods that they invoke; this list is specified through the **set_trigger_event** method (described below).

The methods of the **GraphDialoger** class are as follows:

- **initialize: string** The **initialize** method performs all initialization for a presentation of an object of class **Graph** using the **graph** specific editor. It returns an object identifier in the form of a string; the calling program should place this string in an O_2Look resource named “dialoger”. (An example of this may be seen in Section 6.5).

  set_trigger_event (event: integer, target: Object, method_name: string)

- The **set_trigger_event** method : establishes a call-back link between a user action and a method that administers that action. Once this link is established, the method is invoked automatically whenever the user takes the specified action. Call-back methods are useful whenever the default response of the **graph** editor to a user action is not sufficient. (However, a call-back method cannot override the default action of the **graph** editor.)

  For example, if the user clicks the middle mouse button on a node to select it, the **graph** editor takes care of highlighting the node to show its selected state, but it does nothing else. If any other action is desired, that action would need to be coded in a method, and a call-back link established between the method and the action of selecting a node. Thereafter, whenever the user clicks the middle mouse button on a node, it will be highlighted and the specified method will be invoked automatically.

  A call-back link is established by specifying the three arguments of the **set_trigger_event** method.

  - event describes the user event to be linked to a method. It may be any of the following integers:

    0 — selecting or unselecting a node

    A node is selected or unselected by clicking the left mouse button on it. The default action of the **graph** editor is to highlight a selected node (according to the style specified in the resources **selBorder** and **selThickness**), and to remove the highlight from an unselected node. Also, if the **autoLinkSelect** resource is set to true, the **graph** editor will automatically select a link if both of its nodes are selected. The specified call-back method will be invoked with three arguments:

    method_name (*arg1*: **Graph**, *arg2*: **Node**, *arg3*: **integer**)

    where *arg1* is the **graph** object on display, *arg2* is the node being selected or unselected, and *arg3* is 1 if the node was selected or 0 if it was unselected.

    Note that the user is allowed to select nodes only if the **selectProcess** resource is set to true.

    1 — selecting or unselecting a link

    A link is selected or unselected by clicking the left mouse button on it. The default action of the **graph** editor is to highlight a selected link (according to the style specified in the resources **selColor** and **selThickness**), and to remove the highlight from an unselected link.

The specified call-back method will be invoked with three arguments:

method_name (*arg1*: **`Graph`**, *arg2*: **`Link`**, *arg3*: **`integer`**)

where *arg1* is the **`graph`** object on display, *arg2* is the link being selected or unselected, and *arg3* is 1 if the link was selected or 0 if it was unselected.

Note that the user is allowed to select links only if the **`selectProcess`** resource is set to true.

2 — pasting a new node

A node copied or cut from another presentation may be pasted onto the graph using the usual O_2Look copy-and-paste or cut-and-paste operations. The default action of the **`graph`** editor is to accept the paste operation as normal.

The specified call-back method will be invoked with two arguments:

method_name (*arg1*: **`Graph`**, *arg2*: **`Node`**)

where *arg1* is the graph object on display, and *arg2* is the newly-pasted node.

3 — deletion of a node

A node is removed from a graph through the normal O_2Look cut operation (that is, holding the Control key plus clicking the middle button on the node, and dragging it off the graph, usually to the Clipboard). The default action of the **`graph`** editor is to erase from the graph display the node and all links attached to it.

The specified call-back method will be invoked with two arguments:

method_name (arg1: **`Graph`**, *arg2*: **`Node`**)

where *arg1* is the graph object on display, and *arg2* is the node being deleted.

Note that the user is allowed to remove nodes only if the **`nodeCutProcess`** resource is set to true.

4 — insertion of a link (after)

A link is added between two nodes by holding the Control and Shift keys down, then clicking the right mouse button on one node and dragging a line to the other node. A multi-line link may be created by releasing the button one or more times against the graph background. The default action of the **`graph`** editor is to display the new link according to how it was constructed.

The specified call-back method will be invoked with two arguments:

method_name (arg1: **Graph**, *arg2*: **Link**)

where *arg1* is the graph object on display, and *arg2* is the link that has been inserted.

Note that you can only create links if the **linkNewProcess** resource is set to true.

Note also that this callback is triggered after a link has been inserted in the graph. The programmer cannot interfere in the link creation process. Another callback is intended for this purpose (see below).

5 — dragging a rectangle

Clicking the right mouse button down and dragging it will draw a rectangle on the screen. The **graph** editor takes no default action when this is done, except to display the rectangle. A call-back method may be specified which performs something useful, such as the addition of a new node at that point.

The specified call-back method will be invoked with five arguments:

method_name (arg1: **Graph**, *arg2:* **integer**, *arg3:* **integer**, *arg4:* **integer**,

arg5: **integer**)

where *arg1* is the graph object on display, and *arg2* through *arg5* are respectively the *x* and *y* coordinates of the top left corner of the box, and the width and height of the box. The four integer values are expressed in pixels.

Note that the user is allowed to drag out a rectangle only if the **nodeNewProcess** resource is set to true.

6 — insertion of a link (before)

A link is added between two nodes by holding the Control and Shift keys down, then clicking the right mouse button on one node and dragging a line to the other node. A multi-line link may be created by releasing the button one or more times against the graph background. The default action of the **graph** editor is to display the new link according to how it was constructed.

The specified call-back method will be invoked with two arguments and returns a result:

method_name (arg1: **Graph**, *arg2:* **Link**) **: integer**

where *arg1* is the graph object on display, *arg2* is the link being inserted and the result of the method is an integer.

The effective insertion of the new link depends on the result of the callback method. If it returns 0, the insertion is aborted; in

other cases, the insertion is confirmed and is realized after the callback returns.

Note that the user is allowed to create nodes only if the **linkNewProcess** resource is set to true.

- **target** specifies the object to which the call-back method is to be sent. This is typically an object of class **Graph** or one of its subclasses; but in fact it can be any object at all.
- **method_name** is the method to be invoked when the user action specified in the **event** argument takes place. The method must be defined as a property of the class to which the **target** object belongs. Note that the signature of this method must conform to that described (above) for the relevant event.

• **select_all**

This method marks all nodes and all links as selected.

• **clear_all**

This method marks all nodes and all links as unselected.

• **select_node (node: Node)**

This method marks the specified node as selected, all other nodes and links as unselected.

• **select_link (link: Link)**

This method marks the specified link as selected, all other links and nodes as unselected.

• **extend_select_node (node: Node)**

This method marks the specified node as selected; the selected or unselected state of other nodes and links is left unchanged.

• **extend_select_link (link: Link)**

This method marks the specified link as selected; the selected or unselected state of other nodes and links is left unchanged.

• **toggle_select_node (node: Node)**

If the specified node is selected, this method marks it as unselected; if it is unselected, it is marked as selected. All other nodes and links are marked as unselected.

- **toggle_select_link (link: Link)**

If the specified link is selected, this method marks it as unselected; if it is unselected, it is marked as selected. All other nodes and links are marked as unselected.

- **extend_toggle_select_node (node: Node)**

If the specified node is selected, this method marks it as unselected; if it is unselected, it is marked as selected. The selected or unselected state of other nodes and links is left unchanged.

- **extend_toggle_select_link (link: Link)**

If the specified link is selected, this method marks it as unselected; if it is unselected, it is marked as selected. The selected or unselected state of other nodes and links is left unchanged.

- **node_is_selected (node: Node): boolean**

If the specified node is selected, this method returns **true**; otherwise, it returns **false**.

- **link_is_selected (link: Link): boolean**

If the specified link is selected, this method returns **true**; otherwise, it returns **false**.

- **add_node (node: Node)**

This method adds the specified node to the graph at the location specified by its **position** attribute or according to the active layout.

- **add_unmanaged_node (node: Node)**

This method is identical to the previous one except the node is not displayed on the graph. The new node will be displayed only when the **manage_node** primitive will be called. Using this function can be useful for applications that add nodes on a graph displayed with a constraint layout. The application can add a node, links it to already mapped nodes, and manages the new node. The new node will thus appear directly at a good

position.

- **manage_node (node: Node**)

This method is used to display a node inserted using **add_unmanaged_node**.

- **show_node (node: Node)**

This method forces the graph to scroll in order to make the specified node visible. If the specified node is already visible, this method does nothing.

- **remove_node (node: Node)**

This method removes the specified node from the graph.

- **add_link (link: Link)**

This method adds the specified link to the graph.

- **add_link_between (nodef: Node, nodet: Node)**

This method creates a new object of class **Link** as a link between the two specified nodes and adds it to graph. Note, however, that this method will be of limited usefulness if the graph uses links which are instances of a *subclass* of **Link** — which will usually be the case.

- **remove_link (link: Link)**

This method removes the specified link from the graph.

- **refresh_node (node: Node, mask: integer)**

This method redisplays the specified node using the given mask.

- **consult_node (node: Node)**

This method retrieves the current value of the specified node, as displayed on the graph, and places it in the corresponding **Node** object. It is as if the **lk_consult** function (see the *O2 Look Manual*) had been performed on the node, except that only the node is affected, and not the whole presentation. This method is particularly useful for determining the

current position of a node that might have been moved, since the node's **position** attribute is updated.

6.5 Programming example using GraphDialoger

The following program shows how to use the **lk_specific** mask function, the **graph** editor and the **Graph**Dialoger. Firstly create a class **Person** and create three named objects of this class **Sam**, **Lana** and **Sue**.

To display a simple genealogical graph showing that **Sue** is the daughter of **Sam** and **Lana**. To do this, you must firstly import the O_2Kit schema classes and define subclasses that you can manipulate locally. This enables you to supply the missing generic fields, **label** for class **Link** and **content** for class **Node** as well as define the attributes **node** and **links** for the subclass of **Graph**:

```
import schema o2kit
  class Drawable, Bitmap, Image, Graph, Link, Node, GraphDialoger;

class Genealogy inherit Graph
  public type tuple (dialoguer: GraphDialoger,
                     nodes: set(Relative),
                     links: set(Parentage))
end;

class Relative inherit Node
  public type tuple (content: Person)
end;

class Parentage inherit Link
  public type tuple (from: Relative,
                     to: Relative,
                     label: string)
end;
name Tree: Genealogy;
```

The advantage of this approach is that you can define many different subclasses for **Link** and **Node**, with the **label** and **content** fields supplying literally any kind of information.

It also allows you to define specific call-back methods, shown below, for each subclass of **Graph**. Note that you make the type structures of the subclasses public, overriding the automatic private type structure of imported classes.

The class **Genealogy** contains a new tuple attribute, **dialoguer**, to facilitate the use of **Graph**Dialoger methods. You can now initialize the named object **Tree** as follows :

:

```
run body {
  o2 Relative nsam = new Relative, nlana = new Relative,
nsue = new Relative;
  o2 Parentage sl = new Parentage, ss = new Parentage;
/* Define the three nodes */
  nsam->content = Sam;
  nlana->content = Lana;
  nsue->content = Sue;
  nsue->position = tuple (x: 20, y: 30);
  nlana->position = tuple (x: 50, y: 10);
  nsam->position = tuple (x: 10, y: 10);
/* Define the two links */
  sl->drawing = list();
  sl->from = nsue;
  sl->to = nlana;
  ss->drawing = list();
  ss->from = nsue;
  ss->to = nsam;
/* Define the graph value */
  Tree = new Genealogy;
  Tree->origin = tuple (x: 0, y: 0);
  Tree->real_size = tuple (width: 60, height: 40);
  Tree->screen_size = tuple (width: 200, height: 200);
  Tree->nodes = set (nsue, nlana, nsam);
  Tree->links = set (sl, ss);
}
Once the object Tree is initialized, the following code
will display it.
run body {
  Lk_presentation p;
  Lk_mask ma = lk_generic();
  p = lk_present (Tree, lk_object(0, 0, 0,
lk_specific("genetree", 0, 0, "graph", 1, &ma)));
  lk_map (p, LK_MANUAL, 0, 0, 0, 0);
  lk_wait(p);
  lk_delete_presentation(p);
}
```

Executing this program results in the presentation shown in Figure [Ref: plgnone] . Note that the nodes are deliberately out of balance; there is no layout manager in action here. Executing the same program with the resource **`doLayout`** set to true and the resource **`layout`** specified as **`"tree"`** results in the presentation that we saw in Figure [Ref: plgtree].

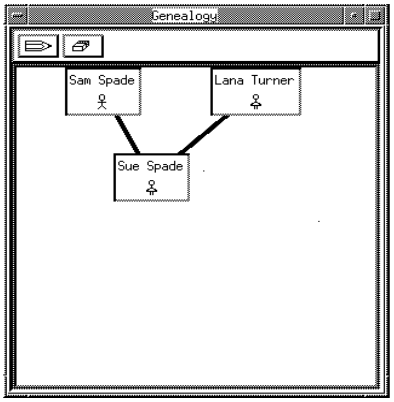


Figure 3.4: A **`graph`** *display without a layout manager.*

Imagine, however, that we wish to use the **`GraphDialoger`**, and so allow the user to add links and nodes to fill out **`Sue`**'s ancestor chart. We must require that the links of the graph must make genealogical sense.

For example, since no person can have more than two parents, we shall forbid the addition of a link from one object of class **`Relative`** to another if that object is already the destination of two links. Furthermore, since an ancestor chart does not deal with siblings, we shall also forbid the representation of more than one child for a parent (that is, more than one link of which the parent is the origin). This requires that we create a call-back method for the class **`Genealogy`**. Let us call it **`check_parents.`**

```
method public check_parents (g: Graph, l: Link) in class Genealogy;
method body check_parents (g: Graph, l: Link) in class Genealogy
{
  o2 Node parent = l->get_origin, child = l->get_destination;
  o2 set(Link) links;
  o2 Link lnk;
  int ok = 1, ct;
  /* Check how many children the parent already has (max allowed = 1) */
  links = self->get_links (parent);
  ct = 0;
  for (lnk in links where (lnk->get_origin == parent))
    ct++;
```

```
 if (ct > 0)
     ok = 0;
  /* Check how many parents the child already has (max allowed = 2) */
   links = self->get_links (child);
   ct = 0;
   for (lnk in links where (lnk->get_destination == child))
     ct++;

   if (ct > 1)
     ok = 0;
 /* If violation, remove the new link */
   if (!ok) {
     (self->dialoguer)->remove_link (l);
   }
```

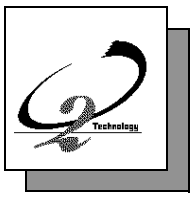
The **GraphDialoger** display is initialized and constructed with the following code :

```
  Lk_presentation p;
  Lk_resource res_graph[1];
  Lk_mask node_mask = lk_generic(), graph_mask, obj_mask;
  o2 GraphDialoger gd = new GraphDialoger;
  char objectstring[16];
  /* Link graph object and GraphDialoger object */
  strcpy (objectstring, gd->initialize);
  Tree->dialoguer = gd;
  /* Put result of initialize method in the "dialoger" resource */
  res_graph[0].name = "dialoger";
  res_graph[0].value = (char*) malloc (strlen (objectstring)+1);
  strcpy (res_graph[0].value, objectstring);


  /* Set call-back for link insertion (event 4) */
  gd->set_trigger_event(4, Tree, "check_parents");

  /* Display the graph */
  graph_mask = lk_specific ("genetree", 1, res_graph, "graph", 1, &node_mask);
  obj_mask = lk_object ("geneobj", 0, 0, graph_mask);
  p = lk_present (Tree, obj_mask);
  lk_map (p, LK_MANUAL, 0, 0, 0, 0);
  lk_wait(p);
  lk_delete_presentation(p);
}
```

6 O2Kit Toolbox Features for the



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